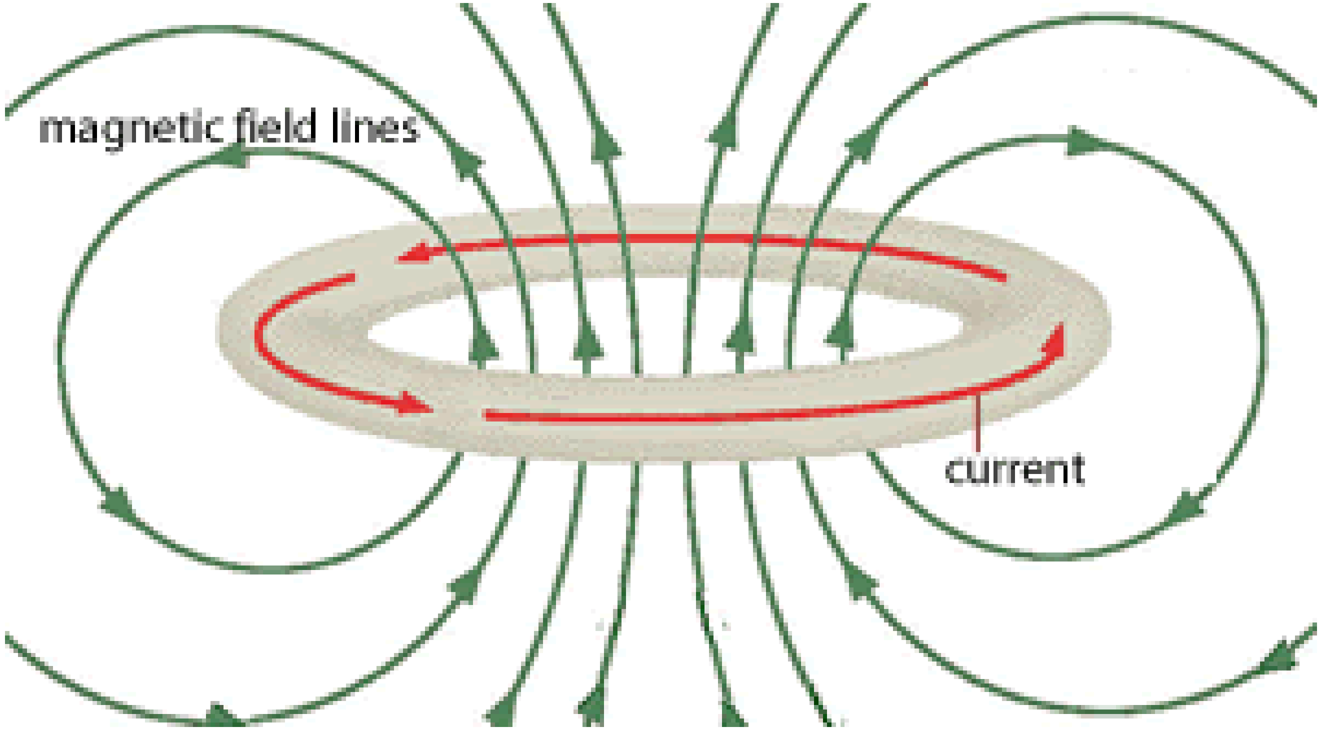
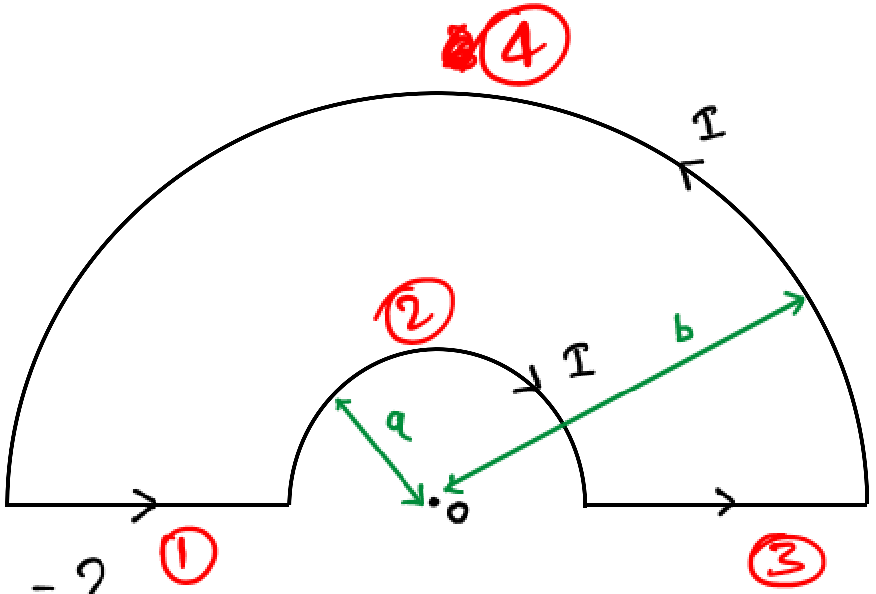
Magnetic Effect Of Current



Lecture - 3

Q.



$B_0 = ?$

Ans $B_0 = \frac{\mu_0 I}{4}\left(\frac{1}{a} - \frac{1}{b}\right) \otimes$

Sol^n

$B_1 = B_3 = 0$

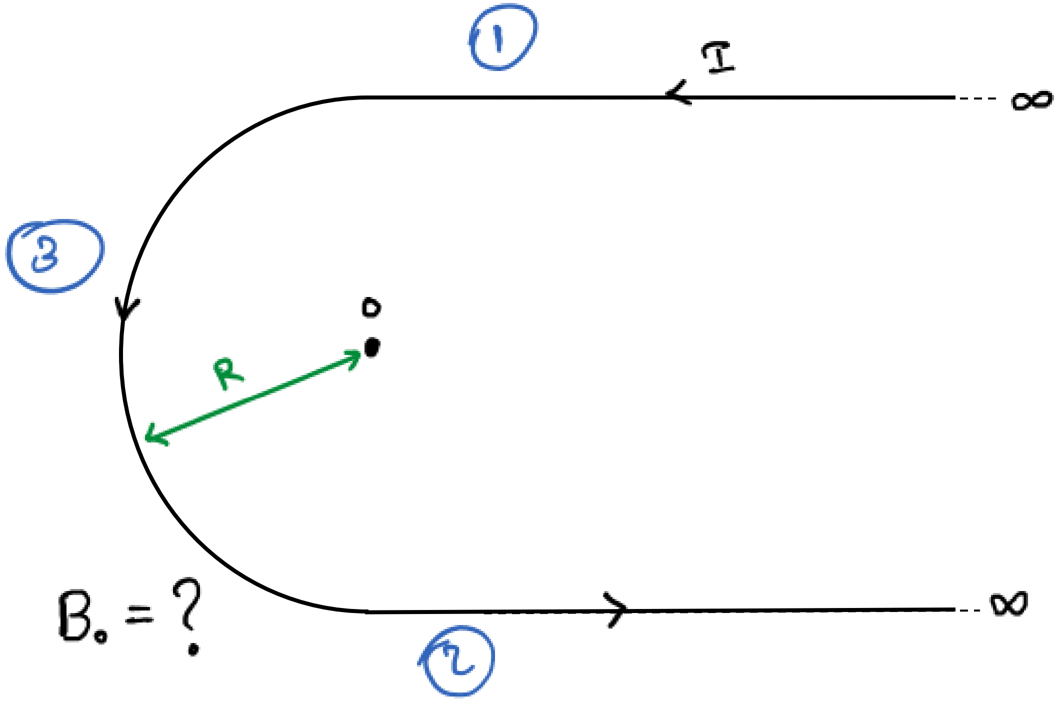
$$B_2 = \frac{\mu_0 I}{2a}\left(\frac{\pi}{2\pi}\right) = \frac{\mu_0 I}{4a} \otimes$$

$$B_4 = \frac{\mu_0 I}{2b}\left(\frac{\pi}{2\pi}\right) = \frac{\mu_0 I}{4b} \odot$$

$a < b$

$B_2 > B_4$

Q.



$B_0 = ?$

Ans $B_0 = \frac{\mu_0 I}{4R}\left[\frac{2}{\pi} + 1\right] \odot$

Sol^n

$$B_1 = B_2 = \frac{\mu_0 I}{4\pi R} \odot$$

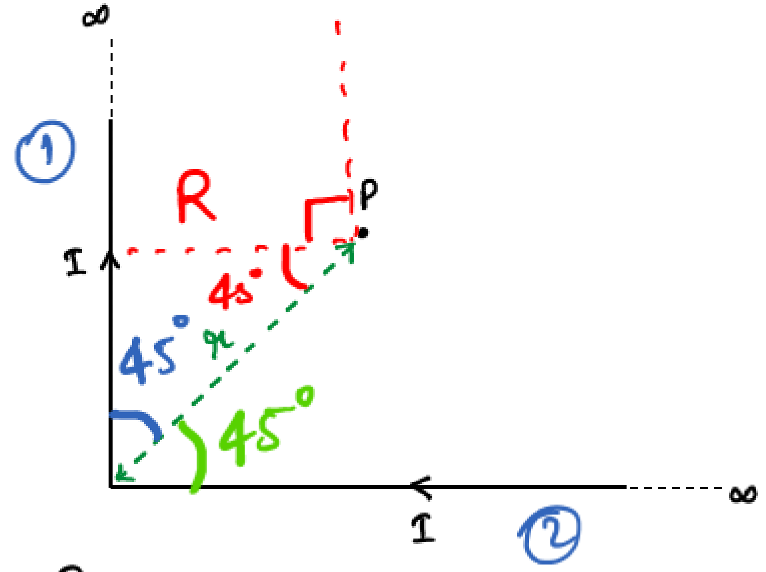
$$B_3 = \frac{\mu_0 I}{2R}\left(\frac{\pi}{2\pi}\right) \odot$$

$$B_0 = (B_1 + B_2 + B_3) \odot$$

$$\boxed{B_0 = \frac{\mu_0 I}{4R}\left[\frac{2}{\pi} + 1\right] \odot}$$

Ans

Q.



$B_P = ?$

Ans $B_P = \frac{\mu_0 I}{2\pi r}[1+\sqrt{2}] \otimes$

1) $\frac{\mu_0 I}{2\pi r}(1+\sqrt{2})$ ✓

2) $\frac{\mu_0 I}{2\pi r}\left(\frac{1}{\sqrt{2}}+1\right)$

3) $\frac{\mu_0 I}{4\pi r}(1+\sqrt{2})$

4) $\frac{\mu_0 I}{4\pi r}\left(\frac{1}{\sqrt{2}}+1\right)$

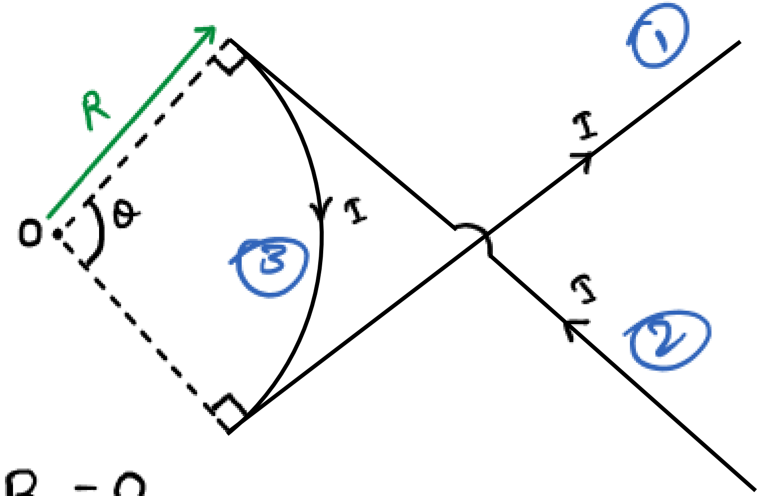
Solⁿ

$$B_1 = \frac{\mu_0 I}{4\pi R}(\sin 90 + \sin 45^\circ) = B_2$$

$$B_1 = B_2 = \frac{\mu_0 I}{4\pi\left(\frac{r}{\sqrt{2}}\right)}\left(1+\frac{1}{\sqrt{2}}\right)$$

$$B_P = B_1 + B_2 \Rightarrow \boxed{B_P = \frac{\mu_0 I}{2\pi r}(\sqrt{2}+1) \otimes}$$

Q.



Ans $\theta = 2$ rad.

$\theta = ?$ if $B_0 = 0$

Sol^n

$B_1 = B_2 = \frac{\mu_0 I}{4\pi R}$ ⊙

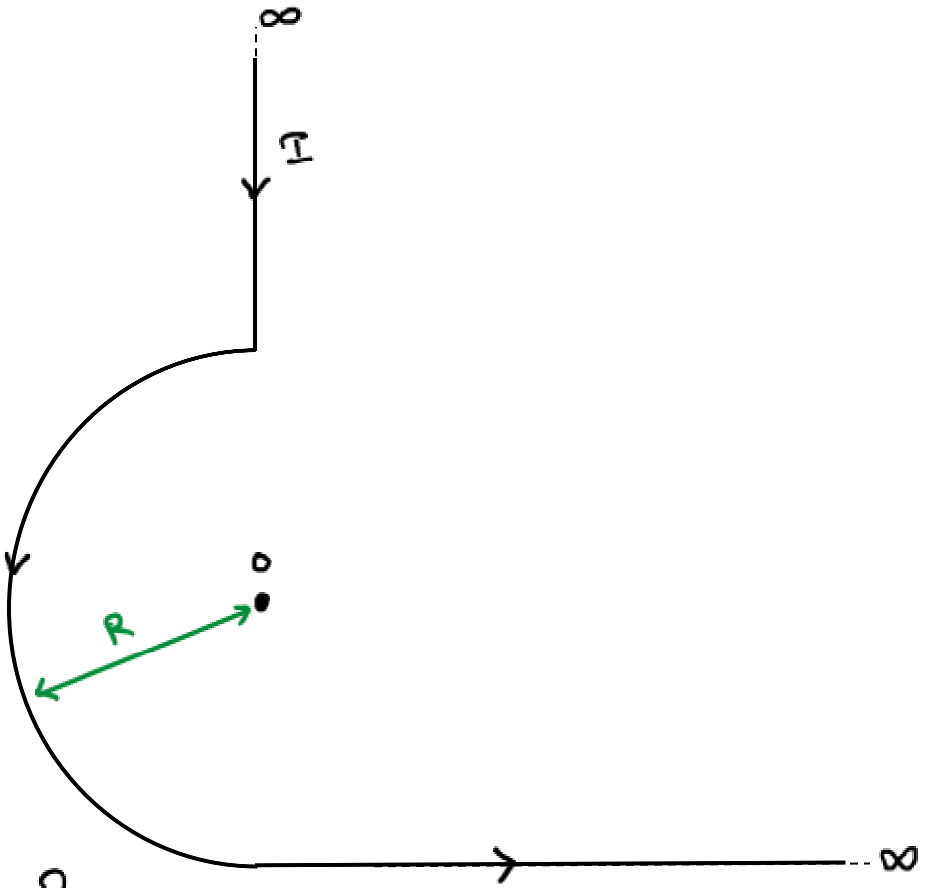
$B_3 = \frac{\mu_0 I}{2R}\left(\frac{\theta}{2\pi}\right)$ ⊗

if $B_0 = 0 \Rightarrow B_1 + B_2 = B_3$

$\frac{\mu_0 I}{2\pi R} = \frac{\mu_0 I}{2R}\left(\frac{\theta}{2\pi}\right)$

$\boxed{\theta = 2 \text{ rad.}}$ **Ans**

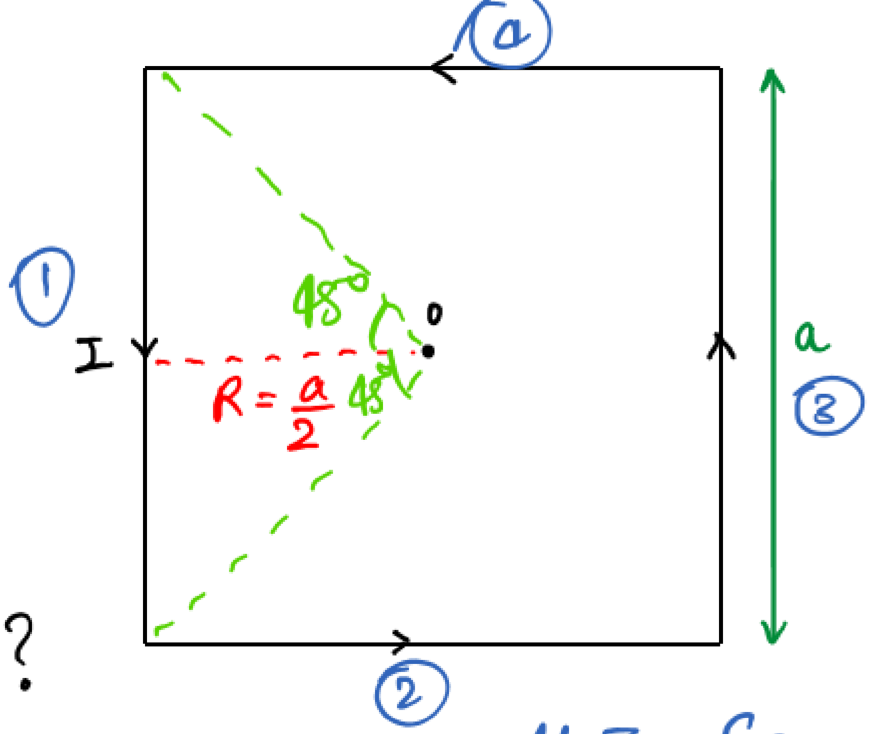
Q.



$B_o = ?$

Ans $B_o = \frac{\mu_o I}{4R}\left(\frac{1}{\pi} + 1\right) \odot$

Q.



$B_0 = ?$

Ans $B_0 = \frac{2\sqrt{2}\mu_0 I}{\pi a} \odot$

1) Zero

2) $\frac{\sqrt{2}\mu_0 I}{\pi a}$

3) $\frac{2\sqrt{2}\mu_0 I}{\pi a}$ ✓

4) $\frac{\mu_0 I}{\sqrt{2}\pi a}$

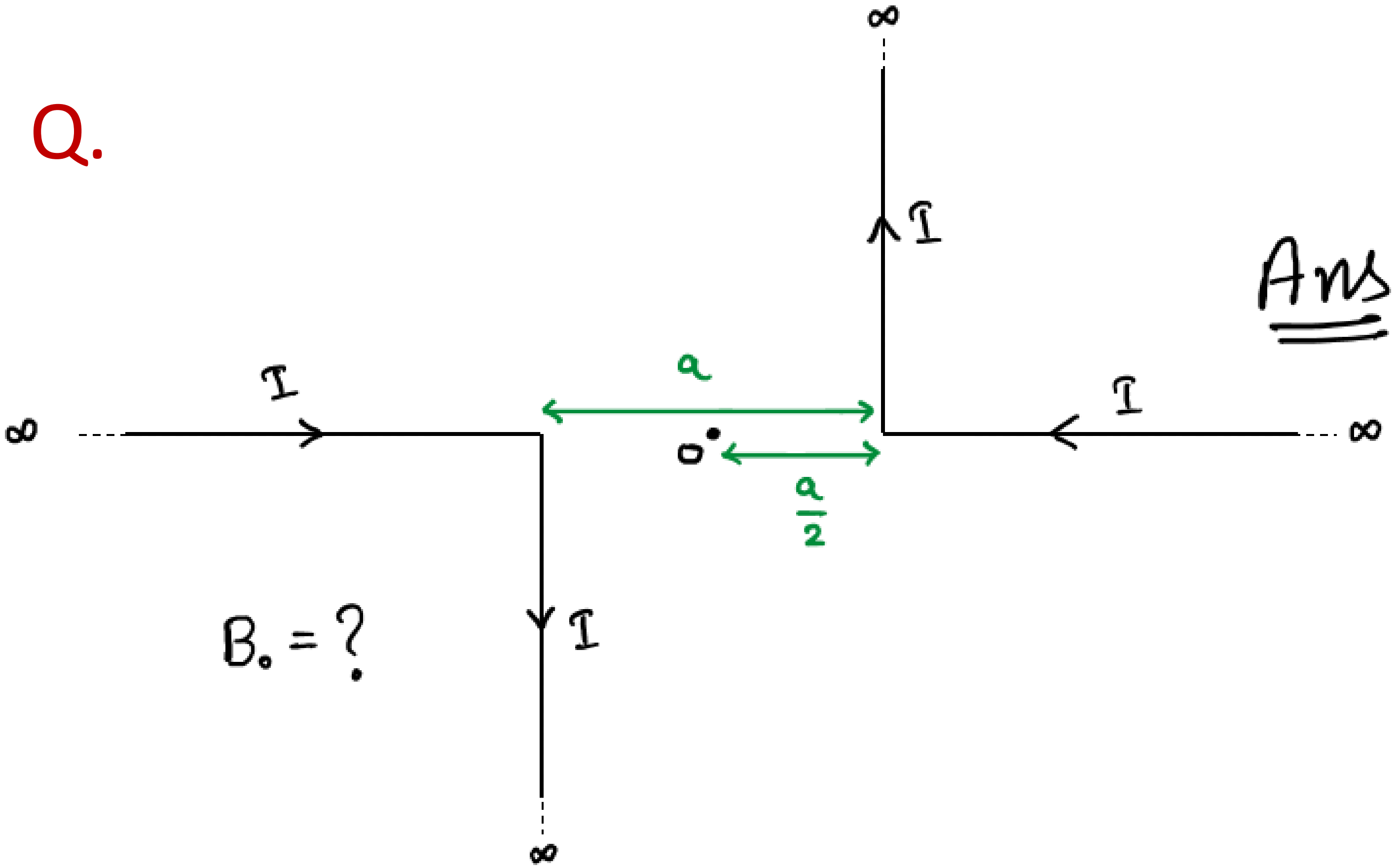
Sol^n

$B_1 = B_2 = B_3 = B_4 = \frac{\mu_0 I}{4\pi R}\left[\sin 45^\circ - \sin(-45^\circ)\right]$

$= \frac{\mu_0 I \sqrt{2}}{4\pi \frac{a}{2}} = \frac{\sqrt{2}\mu_0 I}{2\pi a} \odot$

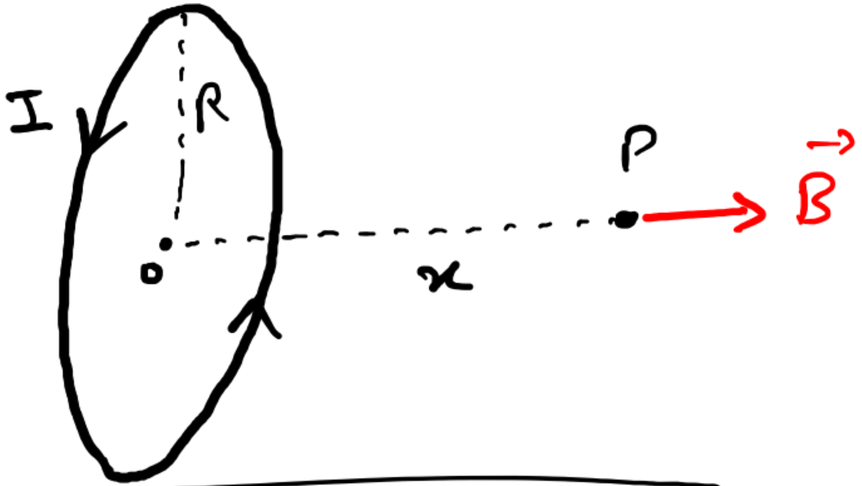
$$B_0 = B_1 + B_2 + B_3 + B_4 = \frac{2\sqrt{2}\mu_0 I}{\pi a} \odot$$

Q.



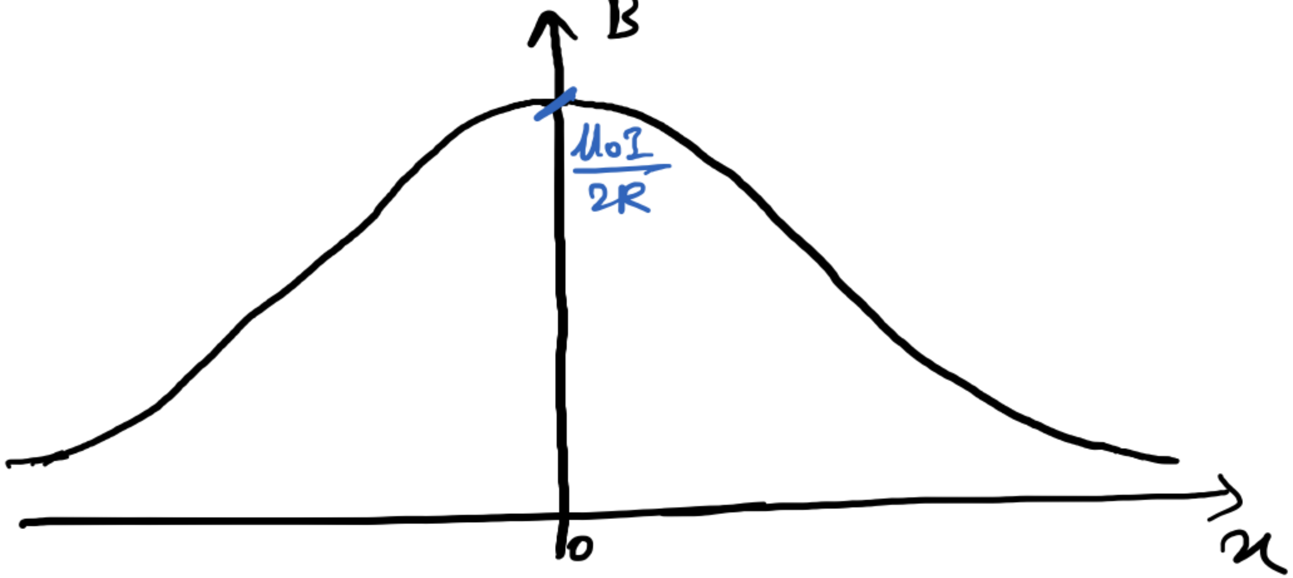
Ans $B_0 = \frac{\mu_0 I}{\pi a} \odot$

Magnetic field at any point on axis of a circular current carrying loop



$$B = \left(\frac{\mu_0}{4\pi}\right) \frac{2\pi I R^2}{(R^2+x^2)^{3/2}}$$

- for N turns $B = \left(\frac{\mu_0}{4\pi}\right) \frac{2\pi N I R^2}{(R^2+x^2)^{3/2}}$
- $\vec{B}$ is along axis of ring
- $\vec{B}$ is max at centre $(x=0)$: $B_{max} = \frac{\mu_0 I}{2R}$



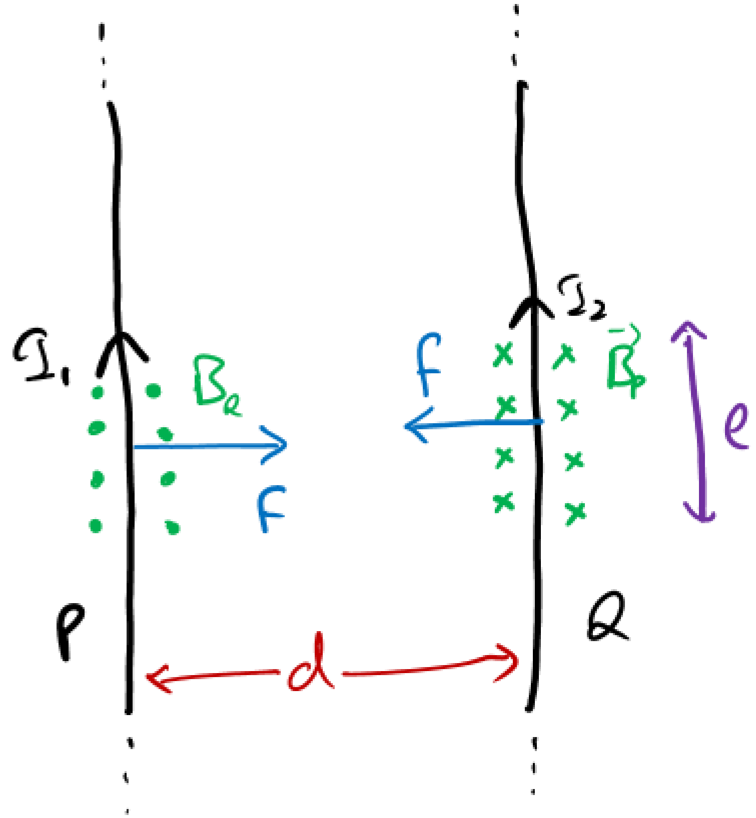
- Two identical co–axial coils (N, I, R same)

- Placed at distance (center to center) equal to radius ('R') of coils.

- Planes of both coils are parallel to each other.

- Current direction is same in both coils (observed from same side) otherwise this arrangement is not called "Helmholtz coil arrangement".

Magnetic Force Between Two Long Current Carrying Parallel Wire



$\vec{B}$ of wire P on wire Q

$$B = \frac{\mu_o I_1}{2\pi d}$$

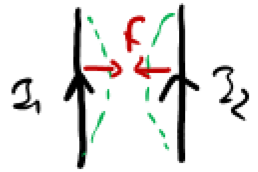
Force on 'ℓ' length of wire Q due to magnetic field of P:

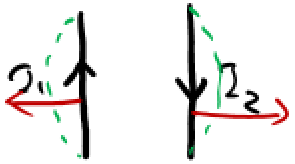
$$F = I_2\, \ell\, B$$

$$F = I_2\, \ell\, \frac{\mu_o I_1}{2\pi d}$$

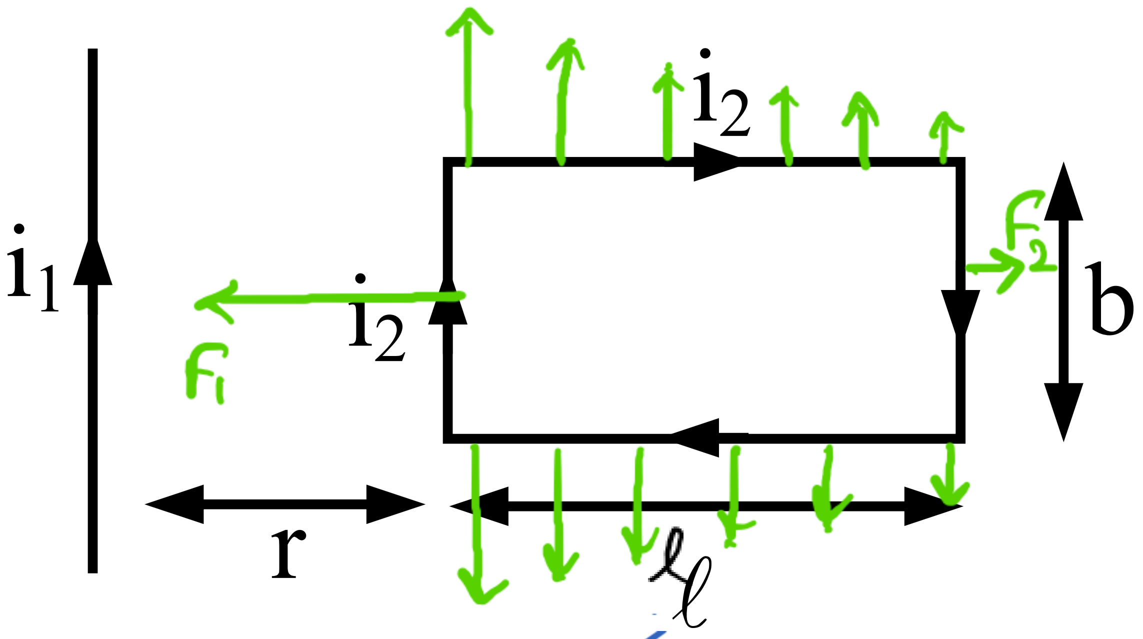
$$\boxed{\frac{F}{\ell} = \frac{\mu_o I_1 I_2}{2\pi d}}$$

*Force per unit length





Q A current carrying very long conductor and a current carrying rectangular loop are kept in the same plane at separation *r* as shown in fig. then magnetic force of interaction between the loop and the conductor is –



(1) $\frac{\mu_0}{2\pi}\frac{i_1 i_2}{(r+\ell)r}$

(2) $\frac{\mu_0}{2\pi}\frac{i_1 i_2(\ell b)}{r(r+\ell)}$

(3) $\frac{\mu_0}{4\pi}\frac{i_1 i_2}{r(r+\ell)}$

(4) $\frac{\mu_0}{2\pi}\frac{i_1 i_2}{(r+\ell)}$

Ans. [2]

Sol. Sol^n

$F = F_1 - F_2$ (attractive)

$$F = \frac{\mu_0 i_1 i_2 b}{2\pi r} - \frac{\mu_0 i_1 i_2 b}{2\pi(r+\ell)}$$

$$F = \frac{\mu_0 i_1 i_2 b}{2\pi}\left[\frac{1}{r} - \frac{1}{r+\ell}\right]$$

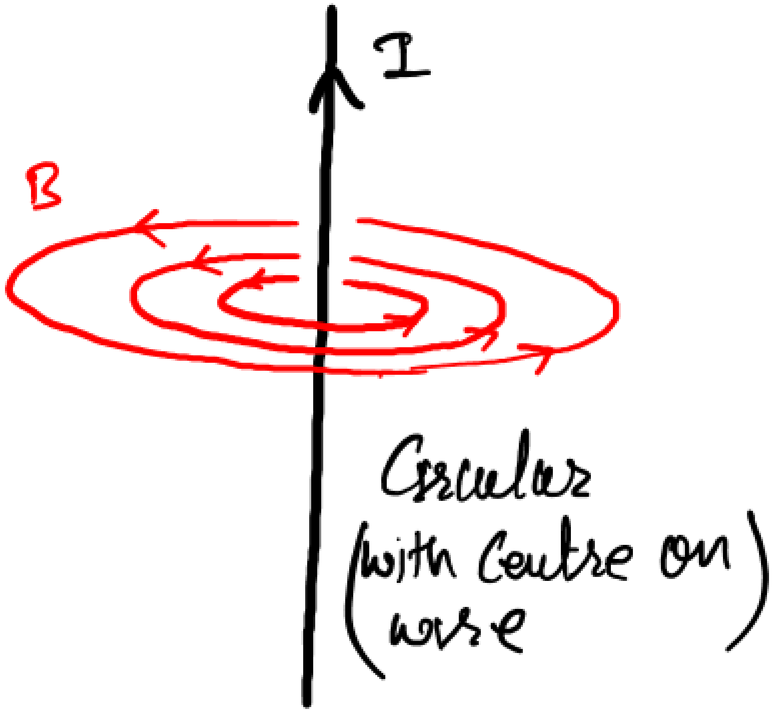
$$F = \frac{\mu_0 i_1 i_2 b}{2\pi}\left[\frac{\ell}{r(r+\ell)}\right]$$

Magnetic Field Lines

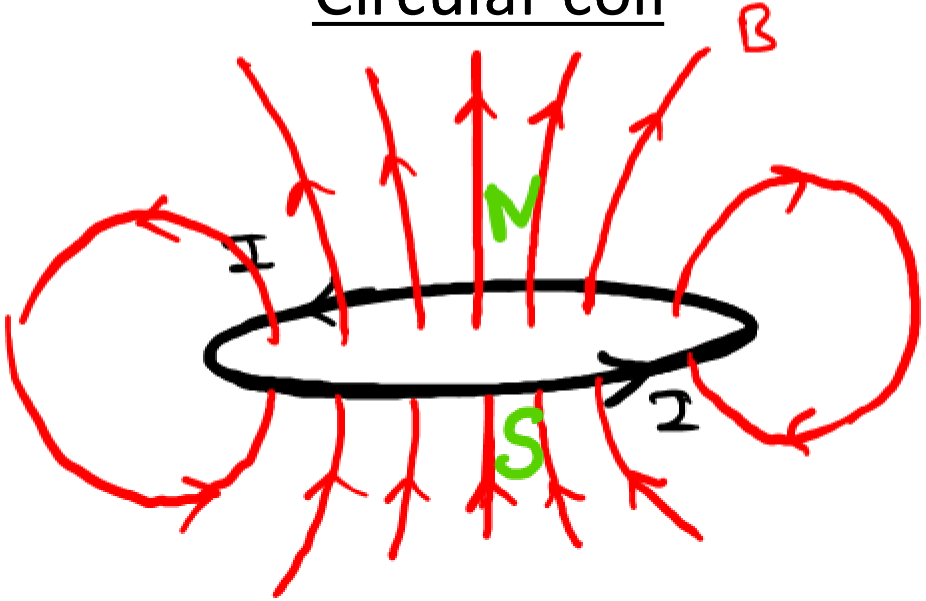
- Magnetic field lines never cross each other.
- The density of the field lines indicates the strength of the field.
- Magnetic field lines always make closed-loops.

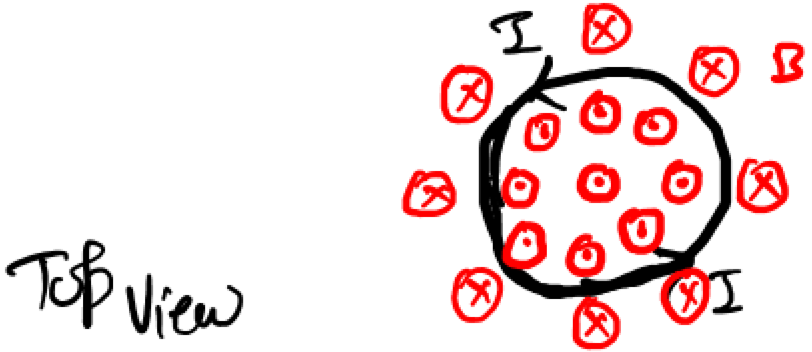
MAGNETIC FIELD LINE DUE TO SOME IMPORTANT STRUCTURE

Straight current carrying wire

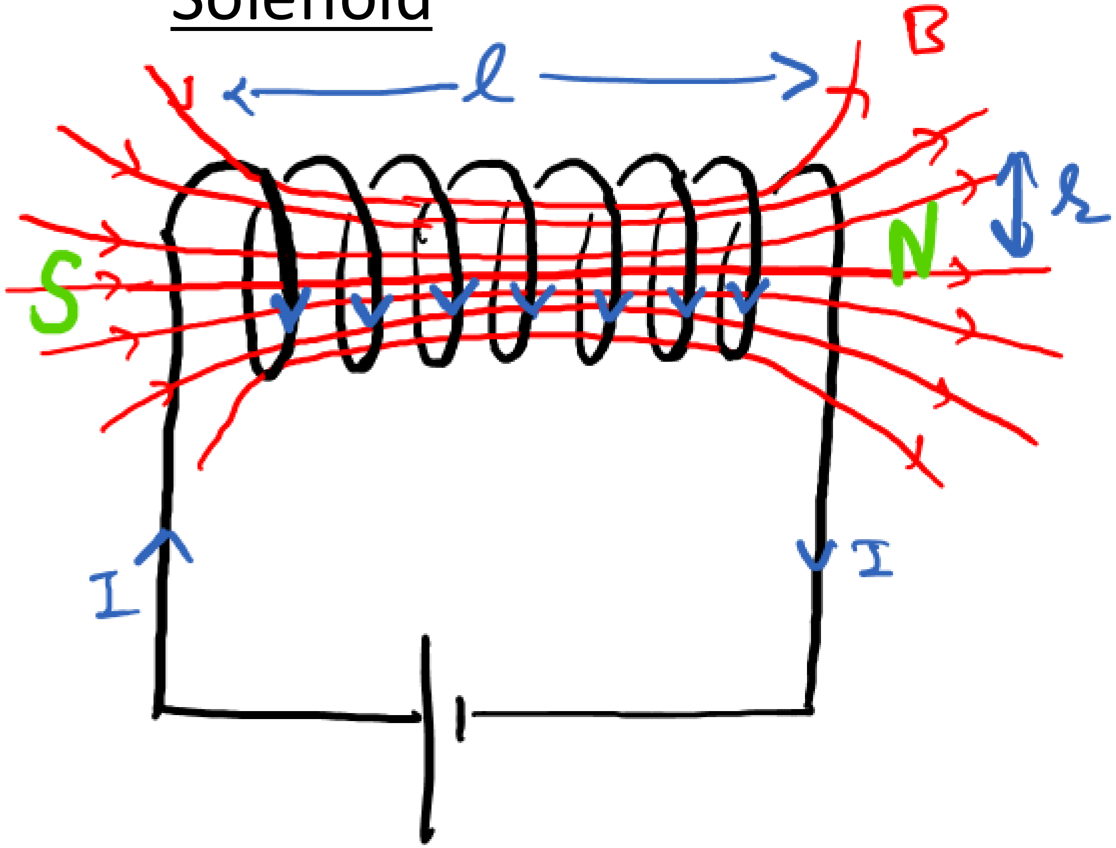


Circular coil

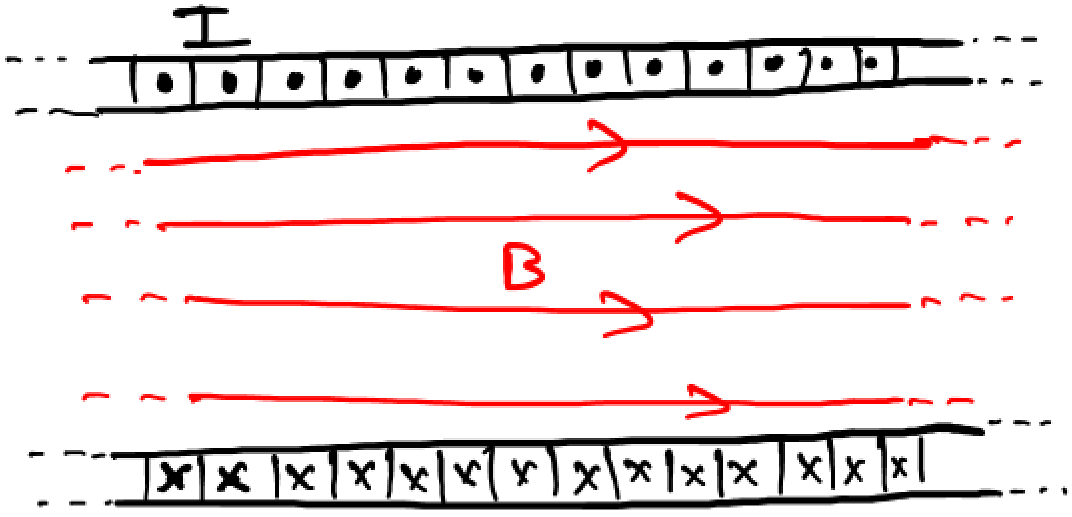




<u>Solenoid</u>



Real Solenoid



Ideal Solenoid ($l >> r$)
(closely wound)

B inside is uniform ; B out is zero (just outside)